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DEVELOPMENT OF PROFESSIONAL CAPABILITIES IN A CHALLENGE BASED LEARNING ENVIRONMENT

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ABSTRACT

Often industry expects university graduates to hit the ground running. One way to deal with this expectation is to offer our graduates opportunities to collaborate with the industry—a collaboration to acquire theoretical skills and acumen in engineering practices and how a business works. Challenge-based learning environments intimated by the CDIO principles, which focus on real-life experiences, external stakeholder involvement, complex problem solving, and a focus explicitly on knowledge application, offer a rich environment that may allow the needed preparation. One of the proposed outcomes for students is the improved acquisition of professional capabilities. However, it is not established yet, whether these professional skills are acquired or strengthened in CBE settings. Professional capabilities focus on four levels; knowing oneself, critically thinking about the problem, collaborating, and having contextual and ethical awareness.
In this study, we surveyed if students perceive improvement in applying professional skills. We particularly questioned professional skills enabling behaviors based on validated questionnaires of EPFL and Univ. Sydney. Additionally, we have gathered and analysed the peer feedback within teams on personal leadership. Contrary to the expectations, leadership skills and professional capabilities are unrelated.

KEYWORDS

Suggest approximately 4 - 6 keywords, separated by commas. The last keyword **must** be “Standards” and include a numerical list of the particularly relevant CDIO Standards, e.g., Standards: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12

INTRODUCTION

The 21st-century workplace shows an increase in complexity, digitisation and diversity (Kamp, 2020). These trends challenge higher education institutions to deliver students capable of dealing with new ways of working. One must have an overview of critical issues in a company and beyond; continuously renew, by collaborating with other disciplines, one's knowledge and use this for new practical applications and interact with different scientific and non-scientific disciplinary stakeholders (Peters et al. 2019), (Dorst, 2017). These critical issues require higher engineering education students to effectively cope with unpredictable circumstances, develop their professional capabilities, deal with complexity and personal development, and meet workplace situations' demands (Lizzio & Wilson, 2007).

The Joint Interdisciplinary Project (JiP) aims to prepare Master's students for entry into the workforce after their studies. In JiP, a ten-week 2nd-year master course contributes to solving impactful, real-life technological challenges provided and supervised by renowned companies. Interdisciplinary student teams are guided by a company coach and are offered academic and industry expertise. The course objectives are:

- LO 1. The ability to integrate (scientific and practical technological) knowledge from different disciplines to solve complex problems
- LO 2. The capacity to evaluate the ethical, scientific and societal consequences of the proposed innovation
- LO3. The ability to create reasonable and relevant research or design, according to the academic and technological standards of the involved disciplines
- LO 4. Demonstrate behavioural competences and skills relevant for teamwork and effective communication with different stakeholders
- LO 5. To carry out regular reflections on professional and personal development and being able to improve upon those reflections

The course in itself follows the CDIO characteristics of the flexible curriculum, diversity of disciplines, culture and academia vs industry, as a point of departure, R&D innovation or design offering reflection on technology and personal Development (Malmqvist et al., 2019). Students work in interdisciplinary project teams and are reviewed by 360 panels of experts on their work. During the course, students reflect on personal leadership skills, the values/beliefs of culture and company, and the team process during the course. Equally, they receive peer feedback from their team members on their leadership skills, and sometimes the company coaches also provide input on the team process. However, the purpose of this paper is not to explore the course design but the perception and measurement of professional capabilities and leadership skills by students in different types of courses.

THEORETICAL FRAMEWORK

Many heve tried to capture the professional capabilities needed to thrive in an academic to a professional environment. Attributes for effective professional development are self-reliance and courage, social understanding and professional consciousness ((Lloyd et al., 2001, Trevelyan, 2019)). Another set of attributes is social competence, collaboration and negotiations with various people, having an eye for new opportunities, taking continuous initiative and functioning in a group, e.g., high participation in group discussions, ability to work in a team, good presentation of information and knowledge, proactive attitude, and taking responsibility for the successful functioning of the group (Semeijn et al., 2006) and Professional capabilities are identified and related to communication, collaboration, contextualisation and responsible behavior, beyond the knowledge of content, methodology and tools (Picard et al., 2021).

In this paper, we have chosen to use the definition of Trede (2017) of the "deliberate professional", as its' description is applicable across various disciplines and allows for a coherent interpretation of the plethora of the many different attributes mentioned in the previous paragraphs. She poses; that "a deliberate professional consciously reflects on who he/she is and acts in the world, making deliberate choices, taking up a position and acting responsibly with deliberation about the consequence of their actions". This description is the result of four characteristics that need to be acquired during higher (engineering) education and is ideally related to a challenge:

- Being aware of the complexity of the workplace practice, cultures and environments
- Being realistic about what can be done concerning existing and changing practices
- Positioning oneself in the field as well as making technical decisions
- Being aware of the consequences of doing and acting in relation to a particular practice.

We have interpreted this as knowing oneself (personal development), realising agency – acting from a conscious act of reasoning, collaborating in context and understanding the contextual environment and responding in an ethically sensitive way.

The central question is:
- **To what extent did students perceive to have acquired professional capabilities in this course?**

Furthermore, leadership skills are currently used for the personal development reflections; we felt this might enhance the professional capabilities, and therefore, the second question is
- **What is the relation between professional capabilities and leadership skills?**

METHODOLOGY

In this study, we have questioned whether students, through reflectional activities and course activities, felt better able to perform particular behavior related to professional capabilities.
The questionnaire has been developed to measure these professional capabilities across various contexts in two Master's programmes of an Engineering School, besides the interfaculty course referred to in this article. All of the Sample contexts include:
Reflective activities on personnel and skills development, some challenges – ranging in openness of the design briefs and "real" life cases, involvement of stakeholders, a level of flexibility in students' choice and a Master's level.

Professional capabilities are measured at four levels:
1st: Personal Development: knowing oneself, Emotional reflexivity and Resilience
2nd: Agency: skills to critically think about the problem at hand and take a stance; evaluate information at a professional level, such as evaluative judgements
3rd: Collaboration, consisting of interprofessional competencies and teamwork.
4th: Contextual Insight concerns contextualisation and ethical sensitivity.
.
The overall model components are derived from Trede's model on professional capabilities explained in her book the Deliberate Professionals (Trede, 2009). Such as having an informed vision, emotional reflexivity, resilience, and taking a stance. Questionnaire questions have been taken from existing and validated questionnaires or qualitative studies, amongst others from the IMPQ (Picard et al. 2021), which investigated professional teamwork skills. Furthermore, the critical thinking white paper from Davies & Stevens (2019) Pearson's talent management offers evaluative judgement and critical thinking as elements.

The response level was 54 out of 180 students taking part in the course, which was relatively low, around 27%, indicating a broader trend of decline in questionnaire responses over the past decades (Fosnacht et al., 2017, Morton et al., 2012). However, Morton (2012) points out that results need not be less accurate, but we need to be aware of the risk of limited validity.

Of these 54, there were 36 males and 18 females. Most of them were Dutch 40% with Indians 20% and other cultural backgrounds like Chinese, Sudanese, Greek and Italian. In the sample

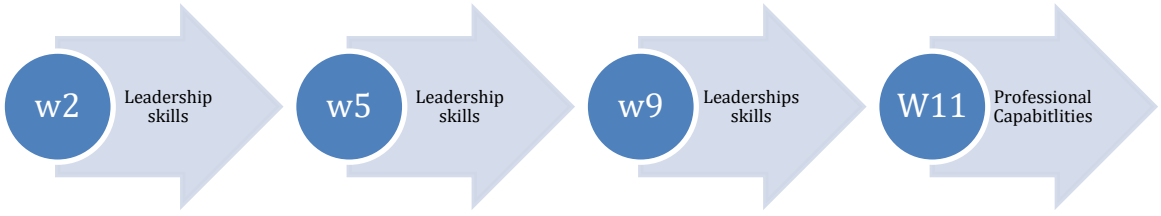
populations, there are 12 different nationalities. The average age group of these 2nd Year Master students was predominantly between 23- and 27, followed by 27- and 32. Very few of them are over 32, and none are under 23. The majority of the students have a background in Mechanical Engineering N= 15. The other backgrounds range from Electrical Engineering, Mathematics, Aerospace Engineering to Industrial Design.

As measured by Cronbach's Alpha, the reliability of the entire questionnaire is .92, which is representative of a highly reliable questionnaire that validly measures the proposed constructs (Nunally, 1978). The separate Cronbach's alphas for each construct are listed below. Despite the somewhat low scores on Self and Communication < .65, we have decided to report on them separately to provide maximum insight into the results.

Table 1. Professional Capabilities- Reliability of Constructs

	items	Cronbachs' alpha	Source
Part 1 – Personal Development		**.87**	
Self	N = 4	.64	Trede
Emotional Reflexivity	N = 6	.74	Trede
Resilience	N = 8	.80	Trede
Part II Agency		**.68**	
Evaluating Information	N = 5	.67	Critical
Critical Stance	N = 4	.66	Critical
Part III Collaboration		**.80**	
Communication	N = 5	.62	IMPQ
Interprofessional Competence	N = 5	.77	IMPQ
Part 4 Contextual insight		**.82**	
Informed Vision	N = 7	.78	Trede
Ethical Sensitivity	N = 4	.85	IMPQ

The students are asked for self-perception of their professional capabilities.



We also used aggregated peer-reviewed data to infer whether they acquired these skills. During the course, students have filled out a leadership questionnaire based on leadership model competencies from the H.R. department of the University; these have been translated into interdisciplinary competencies. Each team member was scored three times during the course on their leadership skills in an online instrument called buddy check by all other team members, resulting in a spiderweb for each team member and provided verbal feedback on how they were doing in the team. The measurement was in W2,5 and 9 of the ten-week course.

The verbal feedback was not captured. However, the aggregated results on cluster level of the week three scoring are available, providing some zero measurements regarding students' professional capabilities. There were 7 clusters, each with different amounts of teams and team members. Only aggregated results are presented from the two most significant clusters, Aerospace and Energy transformation and offshore, containing roughly a representative number of students and equal to those who answered the questionnaire.

The Leadership skills are measured in the following scales

- Innovation: Having a positive Mindset to change
- Innovation Results: Taking responsibility
- Interdisciplinary integrations: open to learning from others and taking initiative
- Interdisciplinary collaboration: working together effectively
- Critical thinking: impact and influence on others
- Reflection: able to reflect on personal performance based on feedback

Note that these labels have been tweaked for practicality's sake in this context. They will be further explained in the results section.

A word of caution on reading the interpretation of the results should be incorporated. This research is very data-driven. Meaning data collection was executed in a natural setting. More importantly, the instruments have been designed for other purposes than researching the particular question raised in the introduction. On the one hand, this provides us with more raw data, which is a good thing. On the other hand, we may find that these data do not entirely satisfactorily yield the needed data to answer the research question.

Hypothesis

The hypothesis is that the leadership's peer feedback questionnaire would provide some sort of zero measurements to establish what students were already capable of doing. The professional capabilities questionnaire would hopefully demonstrate the increase in the acquisition of professional capabilities behavior.

RESULTS

In the results section, we will first look at the aggregates of professional capabilities. In the second part, we will look at the peer review results on Leadership skills. We assumed the leadership skills are likely to correlate with the Professional Capabilities and can be used as a baseline measurement of the Professional capabilities acquired in this course.

Professional Capabilities

We have explicitly not chosen confirmatory factor analysis to analyse the results, as the number of data points does not warrant such an elaborate statistical procedure. We have taken the mean aggregates with standard deviation on the construct level. The reason is that almost all the scores are above 3.8 and below 4.40; a considerable agreement exists between the students on the acquired professional capabilities. As the alpha scores are relatively high, we trust that the data are representative of the students' perceptions. There are slight differences between females and males on average construct scores, with females scoring higher on critical stance, ethical sensitivity and interprofessional competence and males on all the other constructs. Resilience, in particular, shows a significant discrepancy score Means 4.3 for males and 3.9 for females (sign .019 on one way ANOVA). They are showing women to be less resilient.

It is unclear whether the relatively high and homogeneous scores result from learning in this course or because there is a selection bias at the start of the course. Students have to register with a motivation letter to participate in the course and may already be more prepared for this course. We presume, however, it is partly due to the course as the questionnaire has also been released in other Master courses where reflection and challenges played an important role. We found more varied and lower results in the perception scores of students, notably on personal development in the other courses. To further investigate this course, we will now look at the peer-review data that have been collected in week 2 of the course. (For both questionnaires, the list of questions is included in the annexe).

Table 2. Professional Capabilities – Aggregated Means/SD

Professional Capabilities	Mean Average	SD
Part 1 – Personal Development		
Self	4.27	.44
Emotional Reflexivity	4.21	.49
Resilience	4.17	.47
Part II Agency		
Evaluating Information	4.23	.35
Critical Stance	4.26	.41
Part III Collaboration		
Communication	4.22	.48
Interprofessional Competence	4.26	.50
Part 4 Contextual insight		
Informed Vision	4.15	.53
Ethical Sensitivity	4.14	.57

Leadership Skills Peer Review Results Week 2

Table 3 shows the Peer review results of week two on the students' leadership skills. Note that the Means/S.D. are the aggregate of the constructs used in the leadership skill questionnaire. Only cluster Aerospace and Energy and Offshore Engineering have been presented in table 3 as **MEANA** = Aerospace and **MEANE** = Energy. The Energy teams consist of 10 teams of N=40 students, and the Aerospace teams consist of 7 teams of N-34 students. Each team member has an aggregated score of all the team members, including their self-score. Each sub-score thus represents, on average, four persons. The students' self-score could only be retrieved in terms of a differentiation score as opposed to the team score. The differentiation scores range from .99 to 1.18 of the individual score in contrast to the team score. These individual scores have been aggregated further into a mean cluster score across all the teams in a cluster and are presented in table 3.

.

Table 3. Leadership Skills – Aggregated Means/SD for Aerospace and Energy Clusters

	Leadership Skills	**alpha**	**MeanA**	SD	**MeanE**	Sd
	Innovation Skills					
1	Mindset	.80/.87	4.09	.33	4.35	.31
2	Results	.89/.82	4.09	.32	4.6	1.83
	Interprofessional Competence skills					
3	Collaboration	.82/.88	4.19	.35	4.37	.31
4	Influence (critical Thinking)	.80/.88	4.28	.25	4.44	.26
	Empathy					
6	Integration (initiative)	.81/.82	4.19	.27	4.35	.30
7	Reflection and Feedback	.68/.88	4.21	.21	4.39	.31

We notice that the average scores of the Energy Cluster tend to be slightly higher than those in the Aerospace Cluster. An independent sample t-test shows the clusters Aerospace and Energy significantly differ on the construct innovation Mindset (.001), Reflection (.005) and Influence (critical thinking) (.007), with cohens' d effect Sizes of .32, .27 and .25, respectively, suggesting a very moderate impact. However, we observed that teams tended to give team members more or less the same score and relatively higher than lower. Meaning the results are pretty biased. Written feedback notions, such as you should score high to get a good grade or let's encourage each other in the team process and not score too low. It must be emphasised that the buddy check was used only as an instrument to stimulate reflection and not for grading. The reflection was graded based on what they learned from the feedback from the buddy check.

To establish whether the students' did acquire professional capabilities during this course, we intended to use the leadership questionnaire as a zero measurement. Whether we can compare the two questionnaires depends, however, to what extent some of these scales are related to one another. To find out, we conclude with a correlation matrix on the aggregates to see how much these initial scores on leadership corroborate the professional capabilities perceptions of students.

Included in the table is the Pearson Correlation. Only significant correlations are reported. In the blue space, we find the correlations of the Professional capabilities Questionnaire. As we see, the constructs are almost all significantly and positively correlated within the professional capabilities' questionnaire. Meaning there is a positive linear relationship between the variables of the Professional capabilities' questionnaire.

Table 4. Pearson Correlations – Professional Capabilities Variables

	Self	ER	Res	EI	CS	Com	IC	IV
Self								
Emotional Reflexivity	536**							
Resilience	631**	633**						
Evaluative Information	4.98**	-	391**					
Critical Stance	447**	-	330*	484**				
Communication	457**	377**	437**	556**	623**			
Interprofessional Competence	325*	-	281*	448**	556**	646**		
Informed Vision	333*	306*	620**	373**	407**	500**	420**	
Ethic Sensitivity	321*	-	332*	350*	498**	456**	676**	480**

**** correlations is significant at the 0.01 level (2-tailed)**
***correlation is significant at the 0.05 level (2-tailed)**

When we examine the Pearson correlations with the leadership variables, we find that none is significantly correlated to any professional capabilities' variables.
The Pearson correlations for the leadership variable are shared in the table below. We see a strong positive correlation between all the variables except for Innovative Results, where low or no significant correlations could be found.

Table 5. Pearson Correlations – Leadership Skills

	Mindset	InResults	Integration	Coll	CT	Reflection
Mindset						
InRes	265*					
Integration	766**	-				
Collaboration	822**	258*	803**			
CritThin	738**	256*	730**	752**		
Reflection	751**	-	817**	808**	849**	

**** correlation is significant at the 0.01 level (2-tailed)**
***correlation is significant at the 0.05 level (2-tailed)**

We must conclude that the intention we set out at the beginning to use the Leadership Peer review as a zero measurement is not opportune as the measured constructs are unrelated. However, these are all exciting findings we did not exactly set out to find.

DISCUSSION

In this study, we looked at professional capabilities as defined by the model from Trede (2013). Results suggest students perceive themselves at the end of this Challenge-based and interdisciplinary course as being emotionally self-aware, thinking about their work critically, working collaboratively, and they are contextually aware. Although self-perception is perceived as a reliable measure (Picard et al., 2021), we do not have enough information to compare data from a control group or a baseline measurement. Therefore, we do not know whether these data result from the course or are based on self-selection prior to entry into this course.

To mitigate this problem, we intended to use the Leadership skills peer-review results, which we expected to correlate with the professional capabilities. Surprisingly, they did not.

Although students were very positive about their leadership skills and their team members as well at the beginning of the course, it did not predict or relate to the professional capabilities we hoped they would acquire during the course. This latter is quite a finding as professional capabilities and Leadership skills tend to be often mentioned under one breath; they appear to be very distinct features. So contrary to being able to say something about the professional capabilities' students acquired in this course, we can say the questionnaire instruments helped validate two questionnaires for Engineering Higher Education, yielding specific outcomes for both professional capabilities and Leadership skills.

In the future, we will use a time-series analysis to analyse the peer review's leadership skills and their development during the course. The idea is that different clusters may have different levels of expectations. Furthermore, we recommend using professional capabilities across several different courses, as Picard et al. (2021) did in their research, and obtaining sufficient data points to perform confirmatory factor analysis.

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Annex 1

Professional Capabilities Questionnaire

Measured on a 5 point likert scare from 1 strongly disagree to 5 strongly agree.

Personal- Part I
Self - Trede

- Q1 I am aware of my engineering role(s)
- Q2 I have become aware of my passions
- Q3 I have been able to make choices that fit my personal values
- Q4 I can articulate what I need to personally grow

Emotional reflexivity - Trede

- Q5 I tend to reflect and discuss positive/negative experiences
- Q6 I feel more confident
- Q7 I feel more independent – in control
- Q8 I stay calm when under pressure
- Q9 I am better able to make decisions
- Q10 I can empathize better with people in different (professional) positions

Resilience - Trede

- Q 11 I am better able to ask for help
- Q 12 I ask more questions based on my reflective activities
- Q13 I feel confident to share my ideas
- Q14 I have learned from my own mistakes
- Q15 I feel engaged with the offered learning materials
- Q16 I am proactive in seeking new learning experiences
- Q 17 I recognize the need for professional boundaries
- Q 18 I persevere in difficult circumstances

Part II
Informed vision - Trede
Q1 I feel committed to sustainable development goals such as; equitable economic opportunities, environmental awareness, sustainable production etc.
Q2 I am able to envision alternative futures for the improvement of my disciplinary field
Q3 I am aware of the historic development of my disciplinary field
Q4 I am aware of the wider (societal/academic/technical) system in which my discipline operates
Q5 I am aware of the political, national/global contexts
Q6 I am aware how these context shapes individual lives
Q7 I am aware of the different stakeholder perspectives

Evaluating Information – Pearson Critical Thinking
Q8 The ability to evaluate the quality of information presented
Q9 I am aware of the assumptions I make with respect to the problem at hand
Q10I recognize assumptions others are making with respect to a problem discussed
Q11 I validate the inference I make from data (truths or falsification)

Q12 I am aware when certain conclusions are drawn following from information in given statements

Critical Stance – Pearson Critical Thinking
Q13 I interpret and weight evidence and decide if generalization or conclusions are warranted
Q14 I recognize relevant and irrelevant arguments given to solve a particular problem
Q15 I make judgement on the basis of accumulated evidence and reasoning
Q16 I find it easier to establish what to do or what strategies to adopt to the problems we are solving.

Communication – IMPQ (picard)
Q17 I am good at trying to understand the perspective of other team members. D
Q18 I am good at making sure that all the necessary information is shared with other team members. D
Q19 I am good at explaining my ideas in ways that other people can understand. D
Q20 When someone disagrees with me, I am good at paying close attention to see if I can learn something from their alternative perspective. D
Q21 I can normally work productively with another team member even if I am angry or frustrated with them. D

Interprofessional Competence – IMPQ (picard)
Q22 I am good at recognizing the knowledge and skills of different professions involved in a project team. E
Q23 I am good at being sensitive to the way in which different professions may use the same word. E
Q24 I am good at clarifying with people from other professions how their knowledge and skills contribute to each stage of a project. E
Q25 I am good at identifying the skills or knowledge that other professions in the team have, which I should try to develop. E
Q26 I am good at sharing responsibility with the other professions in the team for the overall success of a project. E

Ethical Sensitivity – IMPQ (picard)
Q27 When working on a project, I am good at asking myself if a project like this could have a positive impact on someone else's life. C
Q28 When working on a project, I am good at asking myself if a project like this could have a negative impact on someone else's life. C
Q29 I am good at putting myself in the shoes of someone whose life could be affected by a project's results. C
Q30 I am good at identifying all the people who could be impacted by a project, no matter how directly or indirectly. C

LEADERSHIP SKILLS

PEER REVIEW on Leaderhsip skills

	Innovation Mindset– alphaA .80/alphaE .87	MeanA	SD	MeanE	SD
1.	Sets strong goals for themselves	4.14	.46	4.34	.47
2.	Consistently achieves the goals they've set for themselves	4.15	.40	4.35	.37
3.	Is innovative and resourceful in doing whatever it takes to get the job done well	4.15	.40	4.39	.43
4.	Maintains a positive attitude when dealing with unexpected challenges	4.12	.38	4.42	.30
5.	Puts the needs of the greater good above their own advancement when necessary	4.08	.38	4.26	.46
6.	Initiates activities and takes the lead	3.96	.68	4.19	.39

	Innovation Results alphaA .89/ alphaE .82	MeanA	SD	MeanE	SD
7.	Is continually learning and improving their leadership and performance	3.96	.37	4.19	.39
8	Persuasively and effectively communicates his/her ideas	4.05	.49	4.36	.38
9	Maintains an appropriate balance of immediate needs and longer-range focus	3.96	.40	4.07	.37
10	Makes good decisions	4.07	.28	4.28	.48
11	Is accountable: does what they say they'll do when they say they'll do it	4.28	.38		
12	Prioritises action items and their work, in general, and then, follow through on the priorities they set	4.07	.38	4.27	.47

	Interdisciplinary Integration alphaA .81/alphaE .82	MeanA	SD	Mean E	SD
13	Inspires and supports others to do their best work	4.17	.34	4.25	.43
14	Treats others with respect	4.5	.29	4.78	.24
15	Is resilient in the face of adversity	4.24	.36	4.41	.45
16	Is bold in taking risks when needed	3.98	.38	4.07	.45
17	Understands the needs and priorities of others and is proactive in communicating to others the information upon which they depend	4.07	.40	4.24	.45

	Collaboration alphaA .82/alphaE .88	MeanA	SD	MeanE	SD
18	Is effective at coordinating their tasks with other team-members to increase their effectiveness	4.16	.36	4.29	.48
19	Is good at planning	4.10	.48	4.23	.38
20	Attends team and other meetings in a timely fashion on a regular basis	4.34	.52	4.46	.45
21	Is a constructive force in group work-	4.28	.41	4.49	.30
22	Builds strong relationships with others-	4.18	.45	4.46	.43
23	Understands and highlights the broad outlines of the group's objectives, within the wider context	4.13	.34	4.3	.36

	Critical Thinking alphaA .80/alphaE .88	MeanA	SD	MeanE	SD
24	Understands where their influence lies and how to leverage it	4.15	.34	4.32	.35
25	Generates good ideas	4.23	.32	4.42	.38
26	Is a person of integrity	4.35	.27	4.59	.26
27	Understands why other people act the way they do	4.21	.47	4.29	.38
28	Knows how to navigate between personal and professional relationships	4.36	.28	4.4	.28
29	Is candid and honest when dealing with others	4.37	.37	4.64	.29

	Reflection alpha A . 68/alpha E .88	MeanA	SD	MeanE	SD
30	Listens well to others	4.22	.37	4.47	.39
31	Makes it easy to give feedback to them	4.23	.35	4.44	.40
32	Is effective in providing helpful feedback to others -	4.20	.31	4.38	.34
33	Understands themselves and why they act the way they do	4.24	.23	4.35	.42
34	Is able to act independently/doesn't seek constant approval of others	4.17	.29	4.35	.36

BIOGRAPHICAL INFORMATION

Renate G. Klaassen,(Dr) is a programme coordinator and researcher, working at the 4 TU Centre for Engineering Education at TU Delft and Senior Research at the Delft Institute of Applied Mathematics n Delft. Areas of research interest pertain to content, language integrated learning in higher education, interdisciplinary learning , engineering roles for the Future of Higher Engineering Education and conceptual understanding in engineering education.

Birgit J.E. de Bruin is managing strategic interdisciplinary engineering & educational projects, enhancing strategic liaisons between education and business and has been one of the initiators of the Joint Interdisciplinary Project. Other projects involve Business (context) development, interdisciplinary strategic projects for education, curriculum development, liaisons management, bridging the gap between young talent and their future professional environment in engineering.

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